Sci-Afric Journal of Scientific Issues, Research and Essays Vol. 2 (5), Pp. 222-237, May, 2014. *(ISSN 2311-6188)*
http://www.sci-afric.org

Research Paper

An assessment of Renolith on cement-stabilized poor lateritic soils.

[*a]**Owolabi** T.A and [b]**Aderinola** O.S.

a. Civil Engineering Department, Afe Babalola University, Ado-Ekiti Nigeria
b. Civil Engineering Department, Federal University of Technology, P.M.B. 704, Akure, Ondo State, Nigeria.

* Corresponding Author E-mail: owolabititilayoabimbola@yahoo.com

Accepted March 17th, 2014

ABSTRACT

The influence of Renolith, a polymer-based product composed of latex with cellulose and available in liquid form, on cement-stabilized lateritic soils was investigated to find out any improvement in the strength of the soils. The assessment was carried out on materials from four different borrow pits. After classification of the soils, the unsuitable ones were established in the fourth borrow pit and subjected to stabilization. The ensuing results showed an array of remarkable improvements over each percentage at which cement was kept constant (i.e. at 5% and 10% of the dry weight of soil), and Renolith varied (i.e. at 2.5%, 5%, 7.5%, and 10% of the weight of cement respectively). There was a consistent peak of strength observed at the value of Renolith at 5% of the weight of cement used; though the stronger result was arrived at with higher percentage of cement (at 10% of the dry weight of soil). However, the poorest of the stabilized samples displayed interesting results from the tests in that it's strength indices increased by 7% in Maximum Dry Density; 1,863% in Unsoaked California Bearing Ratio and 200% in Unconfined Compressive Strength after 28 days.

Keywords: cement, classification, lateritic soil, Renolith, stabilization, strength.

INTRODUCTION

When the design phase of any civil engineering construction project is ongoing, the strength parameters of the soil to be used are normally given topmost consideration. In most cases, the soil at a site to be developed may not be ideal in strength from the view point of geotechnical engineering. In highway projects, the strength of a soil determines the suitability of the soil for foundation course. If the strength of the soil is below required standard, then there will be the need to improve the properties of the soil.

However, potential soil problems can be avoided by choosing another site or by removing the undesirable soil and replacing it with desirable one. As a solution to the problems of soils therefore, two different approaches are being simultaneously evolved. The first approach is to adapt the design to the condition at hand. A second approach available, which is of a major interest in this paper, is to alter the properties of the existing soil so as to create a new site material capable of meeting the requirements of the task at hand. Conventional methods of constructing good roads are very costly which compel the adoption of low-cost means which would satisfy the present traffic needs at a minimum cost and at the same time provide bases on which roads of higher specification can be built when traffic on these roads get increased (O' Flaherty, 1974)

Soil stabilization has been widely used as an alternative to substitute the lacking of suitable materials on site. Guidelines and standards have been developed to assist practitioners in designing structures such as roads by means of stabilization. Soil stabilizers like cement and lime; soil additives such as pulverized fuel

ash; bituminous material and so on are being used in various parts of the globe. (Ingles et al,1992). Soil cement usually contains less than 5% cement by weight of soil and is used generally for stabilizing low plasticity soils and sandy soils (Venkatramiah, 1993).
A number of chemicals that are polymer-based stabilizers such as Fujibeton, Terrazyme, among others, are available in the market but there is the need to determine the one most suitably appropriate for a given work. It is, therefore, in realisation of this fact that an investigation was conducted into the Impact of Renolith on poor lateritic soils in Akure South Local Government of Ondo state of Nigeria.
The liquid chemical stabilizer (Renolith) is one of the numerous chemical products in the market developed in Germany by Renolith International from a blend of locally produced synthetic chemical products. According to the manufacturer, the water-soluble chemical is totally non-poisonous, non-combustible, non-corrosive, non-toxic, environmentally safe and user friendly. The product is a synthetic compound with surface-active properties which has been devised to change the hydrophilic (water adsorption) properties of clay minerals to those of hydrophobic (water repellent) ones, yet maintains the strength characteristics of the cement-stabilized soil. One of the main advantages of liquid chemical stabilization is that only a small volume of stabilizing agent is generally required and the cost of stabilizing is lower than that of other methods of stabilization. Compaction has been shown to affect soil structure, Permeability, compressibility characteristics and strength of soil and stress-strain characteristics (Leonards, 1962).
Renolith is a polymer-based product, composed of latex with cellulose. Its liquid form significantly improves the workability of the cement stabilization process in a variety of road subgrade, rail, embankment, and other construction projects. Renolith is a secondary binder because it cannot produce the stabilizing effects on its own but in the presence of cement or any other activator, it reacts chemically to form cementitious compound that contributes to improved strength of poor soil. Also modern cements have higher 28days strength than in the past but the latter gain in strength is smaller (Neville et al, 1987).

MATERIALS AND METHOD

The assessment considered the impact to be induced on cement-stabilized poor lateritic soils using the basic materials such as soil, cement (as primary stabilizer) and Renolith (as secondary stabilizer).
To achieve this, materials were dug up from four borrow pits, each about 2m deep, and subjected to Classification tests such as Natural moisture content test, Specific gravity test, Particle-size distribution test, sedimentation analysis test, Consistency limits test, Unconfined compressive strength test and Compaction test. These were performed on the lateritic samplesaccording to the British Standards BS 1377 (1990); Methods of Test for Soils for Civil Engineering purposes. Stabilization was carried out on the sample which established the suitably poor lateritic soil. Borrow pit four was found to have poor lateritic soil according to the Unified Soil Classification System (USCS) and the American Association of State Highway and Transportation Officials (AASHTO).Therefore, stabilization was carried out on sample four.
After establishing the poor soil, its samples were subjected to different stabilization tests such as Compaction test, California Bearing Ratio test and Unconfined compressive strength test, which involve treating the poor lateritic soil with cement at two constant percentages (5% and 10% of the weight of dry soil) while Renolith was added at pre-determined intervals (2.5%, 5%, 7.5% and 10% of the weight of cement). A study was made on the changes in the compaction characteristics (optimum moisture content, OMC and maximum dry density, MDD), the California bearing ratio, CBR, values and the unconfined compressive strength values, as the stabilizers were added in steps.

RESULTS AND DISCUSSION

Table 1 shows the results of classification tests on the samples that are coarse-grained; Table 2 shows the results of classification tests on the samples that are fine-grained; while Table 3 showed the classification results on the fine-grained samples according to the USCS and AASHTO. Additional information that can be obtained from this Table 3 shows the index properties and subgrade rating of the fine-grained samples. These three tables showing the classification of the soil and results revealed that soil specimen vary in characteristic properties.
Stabilization of the samples, after classification tests, gave amazing results: over each percentage at which cement was kept constant (i.e. at 5% and 10% of the dry weight of soil), and Renolith varied (i.e. at 2.5%, 5%, 7.5%, and 10% of the weight of cement respectively), there was a consistent peak of strength indices observed at the value of Renolith, 5% of the weight of cement used; though better results were achieved with higher percentage of cement (at 10% of the dry

weight of soil), (see Tables 4, 5 and 6).

Environmental friendliness

Renolith was found to be non-toxic on the user as well as on the immediate environment. This is an added advantage when compared with other stabilizers. For example, cement can be dangerous to the skin when not carefully handled. Fly ash, which is caustic, also needs careful handling for safety purposes.

However, the general trend is such that the material picks up strength on addition of the test stabilizer (Renolith) at 2.5%, peaks at 5%, drops at 7.5% and declines further at 10% of the weight of cement used respectively. (Table 4a, 5a, and 6a). There was a significant improvement in the engineering properties of the lateritic soil sample as a result of Renolith being added as a stabilizer as shown in the tables.

From Table 4b, 5b, 6b and figure 1 to figure 12, shows that there was an increment in the soil properties when 5% of cement was added to the lateritic soil without renolith, but when 2.5% of renolith was added to the soil at 5% quantity of cement, the soil characteristics was improved .The optimum increment is at 5% renolith. At 7.5% renolith the characteristics of the soil started to reduce.

When 10% of cement was added to the lateritic soil without renolith, the percentage increment in soil characteristics remains constant, there was an improvement in the soil when 2.5% of renolith was added (10% of cement was kept constant). The optimum was also at 5%. It started to reduce at 7.5% of renolith.

Table 1: Test results for coarse-grained samples

Location of sample	Samples	Specific gravity	Natural moisture content (%)	Particle Size Distribution						Consistency Limits			Compaction	
				Passing No 200 (%)	D_{10} (mm)	D_{30} (mm)	D_{60} (mm)	C_C	C_U	LL (%)	PL (%)	PI (%)	MDD (kNm^{-3})	OMC (%)
Borrow pit 1	1	2.65	4.65	8.90	0.100	0.430	0.980	1.89	9.80	Non-plastic			21.22	7.00
	2	2.66	4.96	6.50	0.165	0.478	1.150	1.20	6.97	Non-plastic			21.42	7.20
	3	2.63	5.02	1.80	0.203	0.272	0.369	0.99	1.82	Non-plastic			16.87	10.70

Table 2: Test results for fine-grained samples

Location of Sample	Samples	Specific gravity	Natural moisture content (%)	Particle Size Distribution			Unconfined Compressive Strength (kNm^{-2})	Consistency Limits			Compaction	
				Passing No 200 (%)	Silt content (%)	Clay content (%)		LL (%)	PL (%)	PI (%)	MDD (kNm^{-3})	OMC (%)
Borrow pit 2	1	2.70	14.58	52.60	44.25	8.35	268.50	-	-	-	17.47	17.30
	2	2.67	11.04	46.50	37.58	8.92	223.50	-	-	-	18.54	13.60
Borrow pit 3	1	2.57	15.68	62.70	38.07	24.63	540.70	38	22	16	17.86	16.70
	2	2.66	3.45	29.00	24.35	4.65	241.10	-	-	-	21.00	12.60
Borrow pit 4	1	2.60	16.28	42.80	21.93	20.87	1181.40	44	21	23	17.48	17.90
	2	2.58	18.74	54.40	33.08	21.32	1066.80	45	25	20	18.00	16.20
	3	2.68	19.68	61.20	31.91	29.29	703.50	61	28	33	16.58	22.20

Table 3: Classification results for samples

Sample Location	Sample Label	Subgrade Rating	Group Index		AASHTO Class	USCS Class
			Value	Rating		
Borrow pit 1	1	Excellent	0	Excellent	A-1b	Well graded sand with silt (SW-SM)
	2	Excellent	0	Excellent	A-1b	Well graded sand with silt (SW-SM)
	3	Poor	0	Excellent	A-3	Poorly graded sand (SP)
Borrow pit 2	1	Poor	4	Fair	A-4	Sandy silt (ML)
	2	Fair	2	Good	A-4	Silty sand (SM)
Borrow pit 3	1	Fair	8	Poor	A-6	Sandy lean clays (CL)
	2	Excellent	0	Excellent	A-2-4	Silty sand (SM)
Borrow pit 4	1	Poor	5	Poor	A-7-6	Clayey sand (SC)
	2	Fair	8	Poor	A-7-6	Sandy lean clays (CL)
	3	Poor	16	Very poor	A-7-6	Sandy fat clays (CH)

Table 4a: Stabilization results for borrow pit 4 with sample 1

Percentag of Laterite	Percentage of Cement	Percentage of Renolith	Compaction		Unsoaked California Bearing Ratio (%)
			MDD (kNm^{-3})	OMC (%)	
100	-	-	17.48	17.90	14.31
95	5	-	17.68	16.00	46.15
95	5	2.5	17.96	16.40	58.78
95	5	5.0	**18.26**	**15.50**	**76.19**
95	5	7.5	17.95	16.40	54.13
95	5	10.0	17.76	16.70	44.60
90	10	-	17.77	16.50	61.88
90	10	2.5	17.96	16.90	82.51
90	10	5.0	**18.25**	**15.90**	**118.17**
90	10	7.5	17.85	16.80	71.30
90	10	10.0	17.66	17.10	51.75

Table 4b: analyses of stabilization results for borrow pit 4 with sample 1

Percentage of Laterite	Percentage of Cement	Percentage of Renolith	Compaction		Unsoaked California Bearing Ratio	
			MDD (%)	Percentage increment	Value (%)	Percentage increment
100	-	-	100	0	100	0
95	5	-	101	1	323	223
95	5	2.5	103	3	411	311
95	**5**	**5.0**	**104**	**4**	**532**	**432**
95	5	7.5	103	3	378	278
95	5	10.0	102	2	312	212
90	10	-	102	2	432	332
90	10	2.5	103	3	577	477
90	10	5.0	**104**	**4**	**826**	**726**
90	10	7.5	102	2	498	398
90	10	10.0	101	1	362	262

Table 5a: Stabilization results for borrow pit 4 with sample 2

Percentage of Laterite	Percentage of Cement	Percentage of Renolith	Compaction		Unsoaked California Bearing Ratio (%)
			MDD (kNm^{-3})	OMC (%)	
100	-	-	18.00	16.20	12.28
95	5	-	18.75	13.70	40.66
95	5	2.5	18.94	13.90	53.30
95	5	5.0	**19.40**	**12.70**	**69.99**
95	5	7.5	18.86	14.10	46.38
95	5	10.0	18.66	14.20	33.98
90	10	-	18.54	14.40	57.23
90	10	2.5	18.65	14.50	101.71
90	10	5.0	**18.94**	**13.60**	**152.44**
90	10	7.5	18.66	14.60	90.24
90	10	10.0	18.45	14.90	65.10

Table 5b: Analyses of stabilization results for borrow pit 4 with sample label 2

Percentage of Laterite	Percentage of Cement	Percentage of Renolith	Compaction		Unsoaked California Bearing Ratio	
			MDD (%)	Percentage increment	Value (%)	Percentage increment
100	-	-	100	0	100	0
95	5	-	104	4	331	231
95	5	2.5	105	5	434	334
95	5	5.0	**108**	**8**	**570**	**470**
95	5	7.5	105	5	378	278
95	5	10.0	104	4	277	177
90	10	-	103	3	466	366
90	10	2.5	104	4	828	728
90	10	5.0	**105**	**5**	**1241**	**1141**
90	10	7.5	104	4	735	635
90	10	10.0	103	3	530	430

Table 6a: Stabilization results for borrow pit 4 with sample label 3

Percentage of Laterite	Percentage of Cement	Percentage of Renolith	Compaction		Unsoaked California Bearing Ratio (%)	Unconfined Compressive Strength (kNm^{-2})
			MDD (kNm^{-3})	OMC (%)		
100	-	-	16.58	22.20	3.93	1290
95	5	-	17.37	17.60	15.98	1840
95	5	2.5	17.46	18.00	19.56	2240
95	5	5.0	**17.76**	**17.00**	**31.72**	**2620**
95	5	7.5	17.47	18.00	21.82	2470
95	5	10.0	17.28	18.20	20.15	2310
90	10	-	17.28	18.60	40.42	2760
90	10	2.5	17.36	18.90	57.35	3360
90	10	5.0	**17.76**	**17.80**	**73.21**	**3870**
90	10	7.5	17.36	19.20	51.95	3660
90	10	10.0	17.18	19.30	36.84	3480

Table 6b: Analyses of stabilization results for borrow pit 4 with sample label 3

Percentage of Laterite	Percentage of Cement	Percentage of Renolith	Compaction		Unsoaked California Bearing Ratio		Unconfined Compressive Strength	
			MDD (%)	Percentage increment	Value (%)	Percentage increment	Value (%)	Percentage increment
100	-	-	100	0	100	0	100	-
95	5	-	105	5	407	307	143	43
95	5	2.5	105	5	498	398	174	74
95	5	5.0	**107**	**7**	**807**	**707**	**203**	**103**
95	5	7.5	105	5	555	455	191	91
95	5	10.0	104	4	513	413	179	79
90	10	-	104	4	1028	928	214	114
90	10	2.5	105	5	1459	1359	260	160
90	10	5.0	**107**	**7**	**1863**	**1763**	**300**	**200**
90	10	7.5	105	5	1322	1222	284	184
90	10	10.0	104	4	937	837	270	170

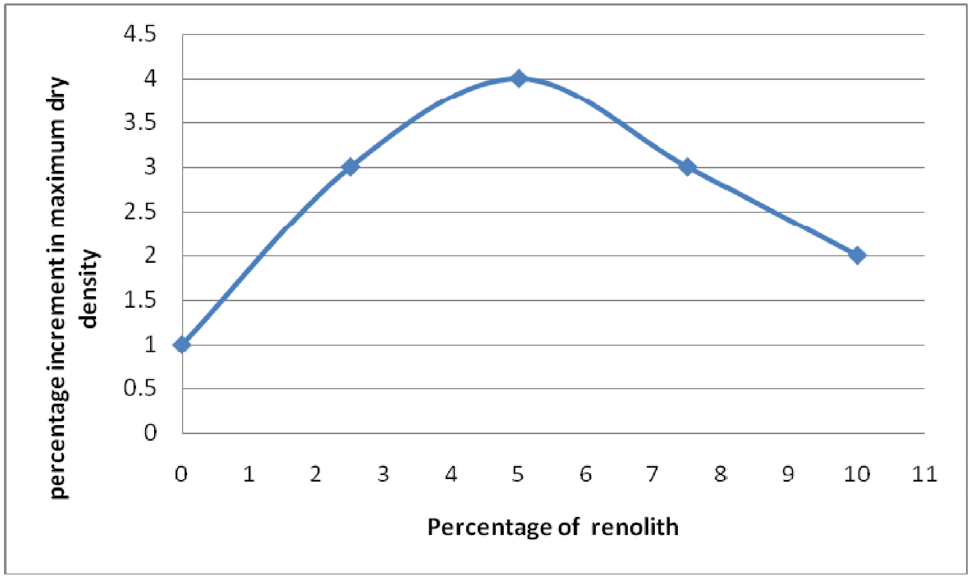

Figure 1: Graph of percentage increment in MDD against % of renolith at 5% of cement for sample 1

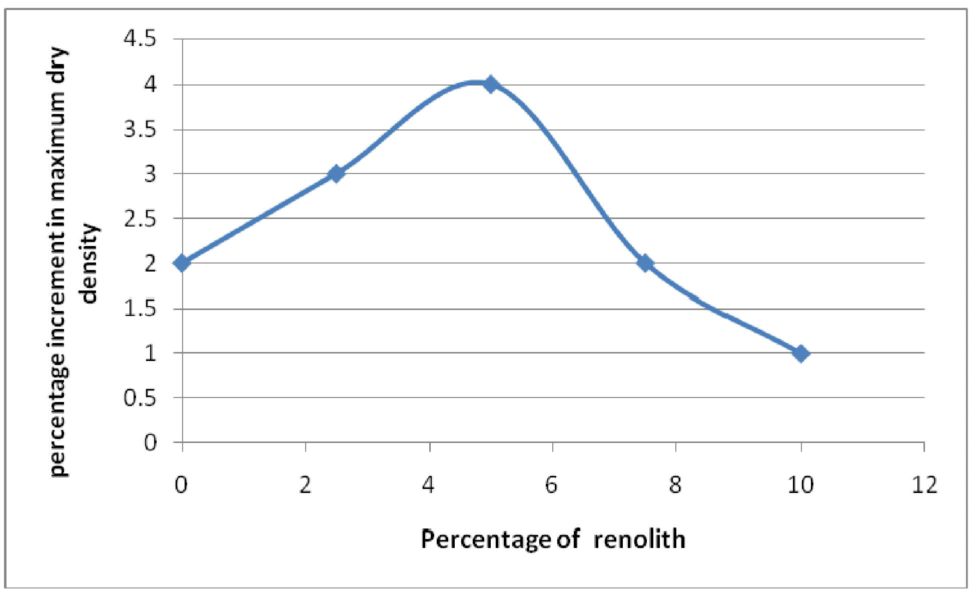

Figure 2: Graph of percentage increment in MDD against % of renolith at 10% of cement for sample 1

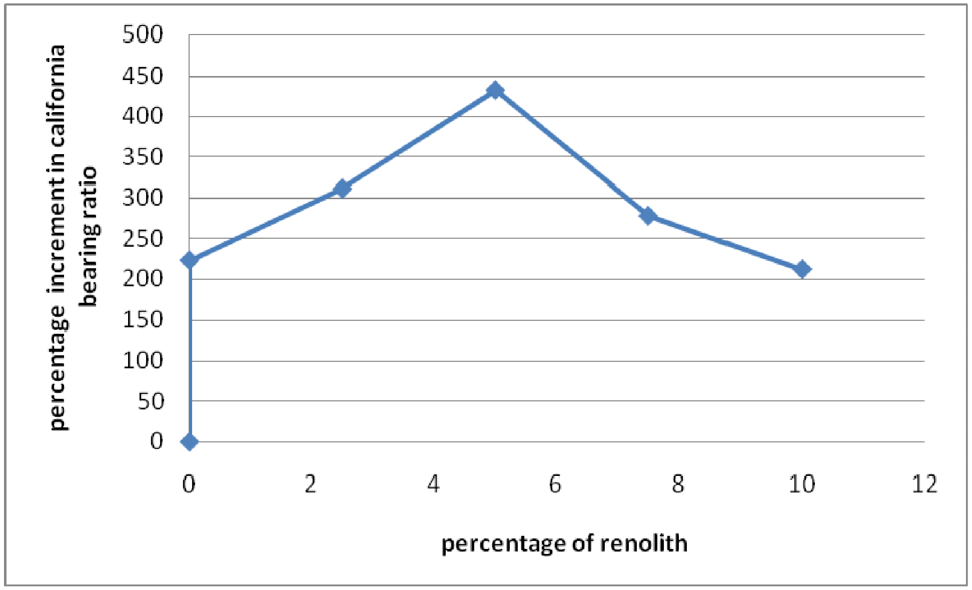

Figure 3: Graph of percentage increment in California bearing ratio against % of renolith at 5% of cement for sample 1

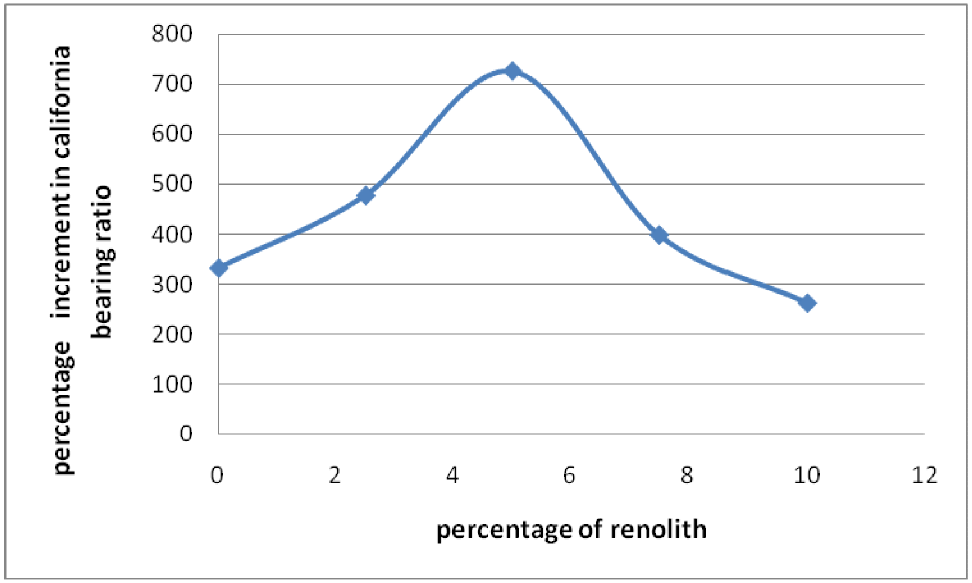

Figure 4: Graph of percentage increment in California bearing ratio against % of renolith at 10% of cement for sample 1

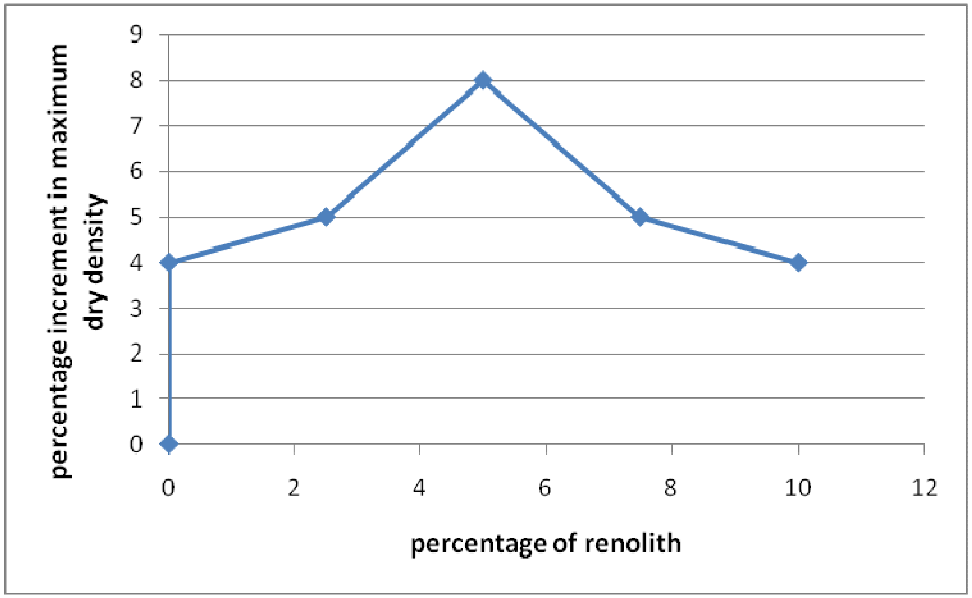

Figure 5: Graph of percentage increment in MDD against % of renolith at 5% of cement for sample 2

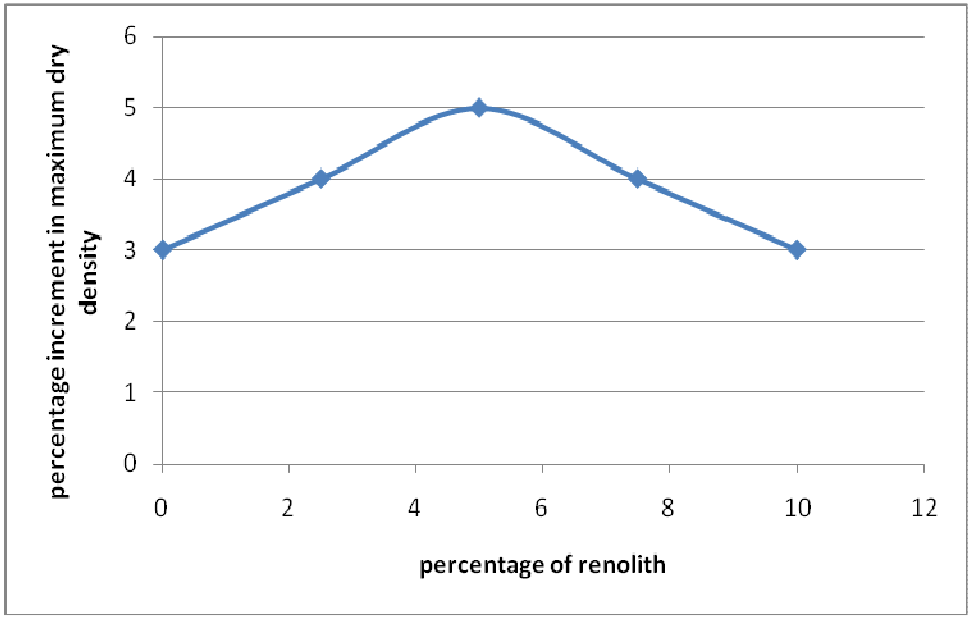

Figure 6: Graph of percentage increment in MDD against % of renolith at 10% of cement for sample 2

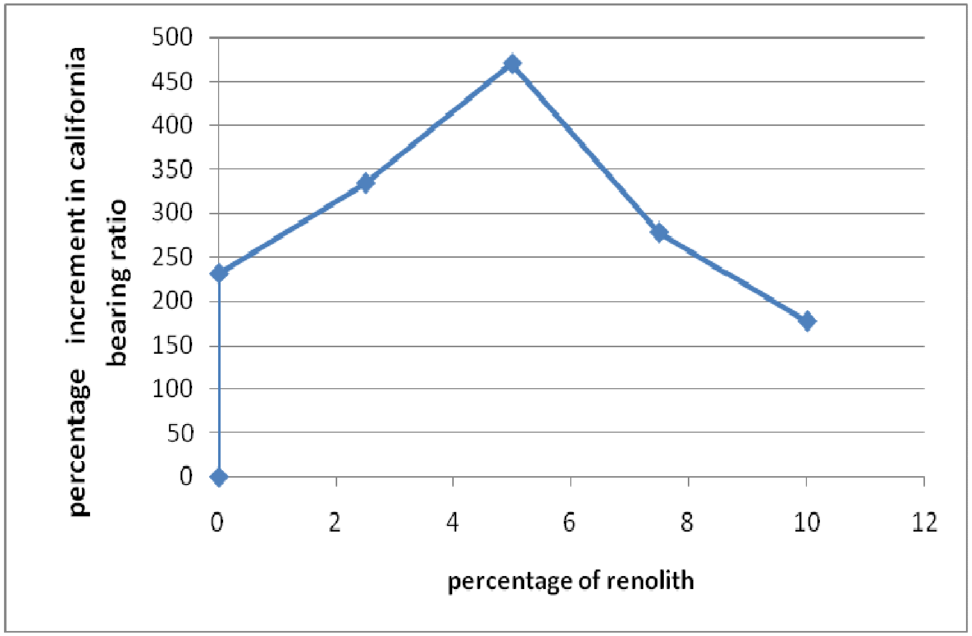

Figure 7: Graph of percentage increment in California bearing ratio against % of renolith at 5% of cement for sample 2

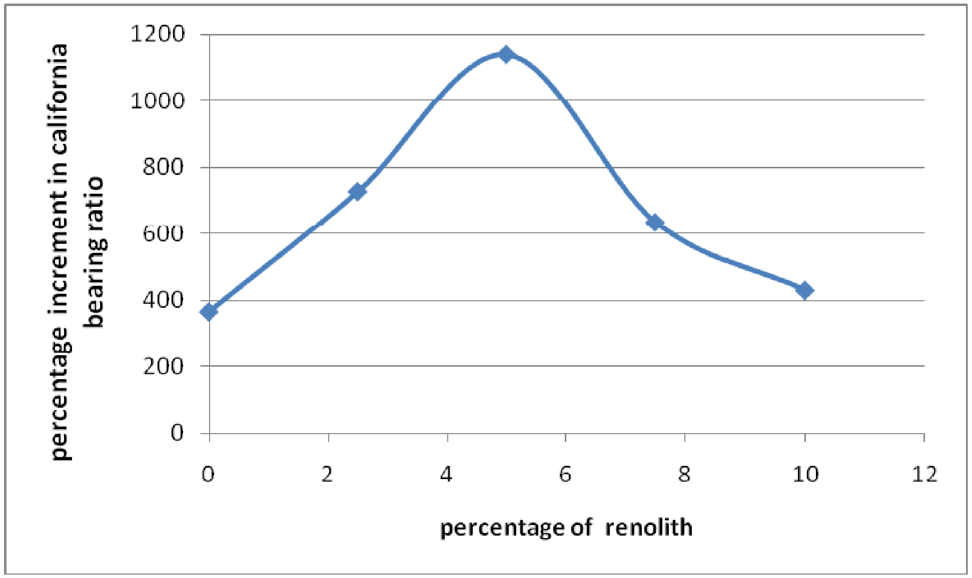

Figure 8: Graph of percentage increment in California bearing ratio against % of renolith at 10% of cement for sample 2

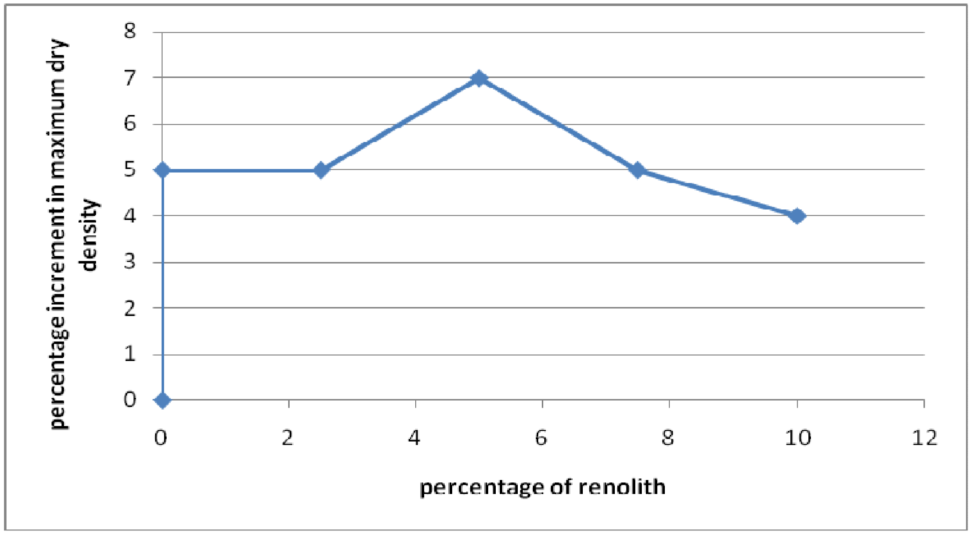

Figure 9: Graph of percentage increment in MDD against % of renolith at 5% of cement for sample 3

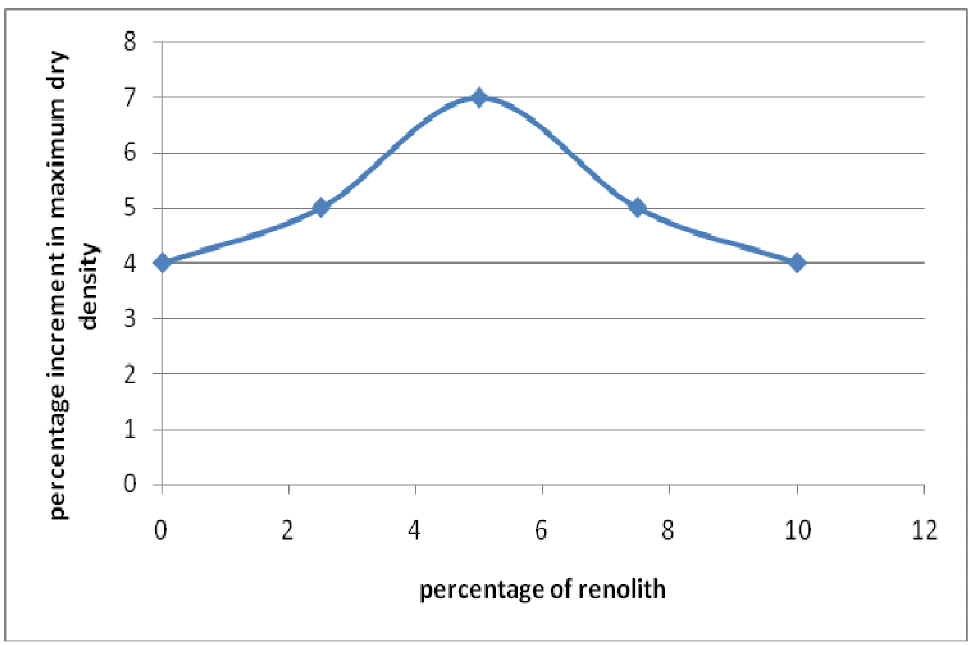

Figure 10: Graph of percentage increment in MDD against % of renolith at 10% of cement for sample 3

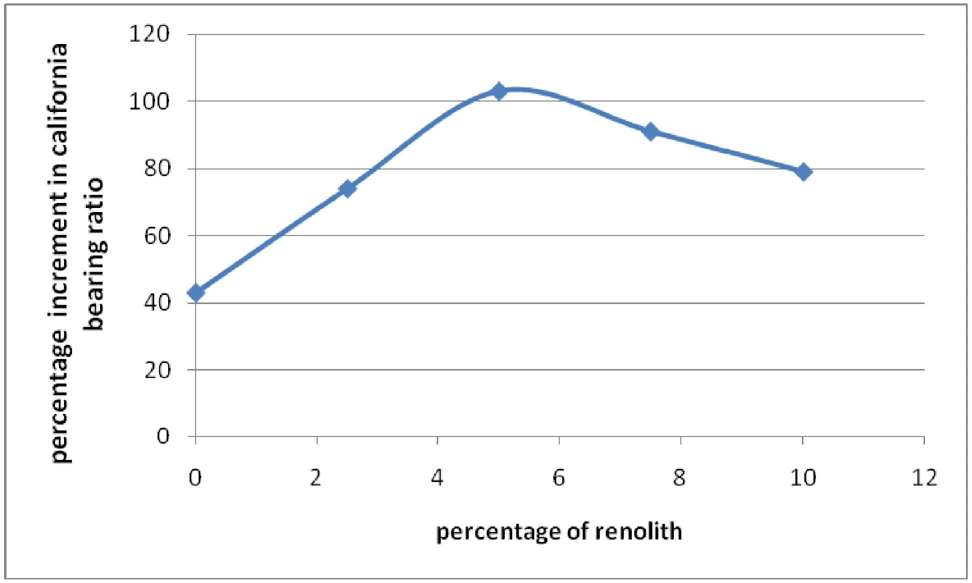

Figure 11: Graph of percentage increment in California bearing ratio against % of renolith at 5% of cement for sample 3

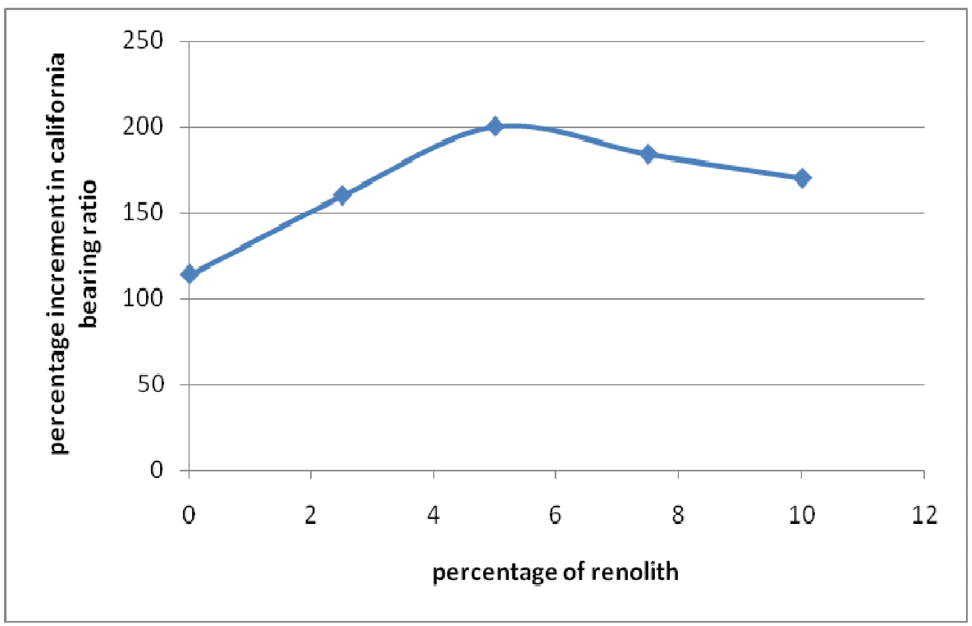

Figure 12: Graph of percentage increment in California bearing ratio against % of renolith at 10% of cement for sample 3

CONCLUSION

The impact of Renolith, a polymer additive, on a cement-stabilized, poor lateritic soil cannot be overemphasized. The results showed an array of interesting improvements at each level of different tests (Compaction, CBR and Compressive Strength, in accordance with different British Standards Codes) conducted on the soils.Renolith significantly improved the strength of the cement-stabilized soil. The best stabilization results for Renolith are at 5% of the weight of cement. This is true for any proportion of cement kept constant at varying percentages of the weight of soil. This translates to substantial amount of cost savings on using the stabilizer with reference to the improvement brought about upon the lateritic sample, as the use of this polymer-creating additive (with an unsoaked CBR value peaked at 73%) further enhances the tensile strength, flexibility and resistance to moisture permeation in stabilized pavement; and not only are these technical benefits accruing from the use of this chemical additive on the soil-cement mixtute, but also the substantial economic and environmental cost savings that would go with the predominantly virtual elimination of imported quarried, graded rock aggregates. In addition to the foregoing, the use of Renolith also translates to a significant amount of time savings for any project as the material quickly bonds with the soil-cement mixture, as well as the time savings on elimination of some earthworks.

REFERENCES

British Standards, 12 - 2. (1971).Portland Cement. British Standards Institution.
British Standards, 1377 – 2.(1990). Methods of Test for Soils for Civil Engineering Purposes – Classification Tests. London.
British Standards, 1377 – 4.(1990).Methods of Test for Soils for Civil Engineering Purposes – Compaction-related Tests. London.
British Standards, 1377 – 7. (1990). Methods of Test for Soils for Civil Engineering Purposes – Shear Strength Test. London.
British Standards, EN 1230 – 2. (2000).Testing Hardened Concrete – Making and Testing Cubes for Strength Tests. London.
Ingles, O. G. and Metcalf, J.B. (1992).Soil Stabilization Principles and Practice.Buitterworths Pty. Ltd., Melbourne, 2(10) 45-60.
Leonards, G. A (1962).Foundation Engineering, McGraw-Hill Book co., New York, USA
Neville, A.M and Brooks, J. J. (1987) Concrete Technology, Longman Scientific and Technical, England.
O'Flaherty C. A. (1974).Highways Engineering, 2nd Edition Vol. 2 Edward Arnold Ltd. London.
Venkatramaiah, C. (1993). Geotechnical Engineering. Wiley Eastern Limited, New Delhi.